§10. Observation of Radial Structure of Edge MHD Modes in LHD Plasmas with L-H Transition

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In the LHD, edge coherent MHD modes such as m/n = 2/3 or 1/2 (m, n: poloidal and toroidal mode numbers), of which the rational surface is located in the plasma edge region of the magnetic hill, are strongly enhanced after L-H transition [1-3]. The excitation of these edge MHD modes degrades the confinement obviously, and stops a further rise in the plasma stored energy by the transition. Accordingly, it is important to clarify the characteristics of these MHD modes and to stabilize them. For this purpose, seven sets of soft x-ray (SX) detector arrays which consist of 20-channel PIN photodiodes were installed inside the vacuum vessel in vertically elongated sections of the LHD. We have used these arrays in order to measure the radial structure of edge MHD modes and studied the global stability of the ETB region.

Figure 1 shows a typical example of an NBI heated plasma with an L-H transition. In this discharge, an L-H transition takes place at t ~ 1.69s. As seen from the time evolutions of W_p and dW_p/dt, rapidly increases with the transition, but quickly saturates in ~20 ms. In the saturation phase of W_p, the m/n = 1/2 edge coherent mode is clearly enhanced, where the SX fluctuation amplitude, δI_{sx}, of the edge coherent modes was extracted using the FFT filter technique. In contrast, the edge coherent mode with m/n = 2/3 mode is suppressed across the transition. The time behaviours of these edge coherent modes sensitively depend on the location with steep pressure gradient.

Figures 2(a, b) show the radial profiles of the SX fluctuation amplitude, δI_{sx}, and the normalized fluctuation amplitude, $\delta I_{sx}/I_{sx}$, where these SX fluctuations have a high coherence with the m/n = 2/3 and 1/2 magnetic fluctuations. It should be noted that the $\delta I_{sx}/I_{sx}$ does not necessarily correspond to an eigenfunction of the edge MHD mode, because of the path integral effect. In addition, the numbers of humps in the profile of $\delta I_{sx}/I_{sx}$ are caused by the path integral effect in the SX emission measurement, and depend on the mode number m. The intensity of SX fluctuation will have a peak when two O-point regions or X-point regions in a magnetic island related to the edge MHD mode are aligned along the line of sight of an SX detector. It will be the minimum when O-point region and the X-point region are simultaneously aligned. The shape of the radial profiles of δI_{sx} can be interpreted qualitatively by the above simple consideration. The peaks of the fluctuation amplitude, $\delta I_{sx}/I_{sx}$, in the low and high field sides (inboard and outboard sides of the torus) are almost comparable. So far, a strong ballooning character is not recognizable. This is also consistent because low m interchange modes do not exhibit a ballooning character [4]. The phase difference among SX channels is also shown in Figs. 2(c, d). The derived phase relation indicates the 'even' or 'odd' character of the m-number, that is, the phase difference between the SX channels at the inboard and outboard plasma edges is ~2π (~π) for an even (odd) m-number. The phase differences for m/n = 2/3 and 1/2 modes are consistent with the m-number determined using the magnetic probe arrays.

In NBI heated plasmas with an L-H transition in the LHD, we have measured the radial structure of edge MHD modes using an SX detector array, the rational surfaces of which were located near or just outside the LCFS defined by the vacuum magnetic surfaces. These radial structures of the edge MHD modes depend on the m-number. In this experimental ETB study, the fluctuation amplitude (δI_{sx}) of m/n = 1/2 rapidly grows across an L-H transition, and leads to quick saturation of the stored energy in a short time, accompanied by H_α spikes which are similar to ELMs.

Reference

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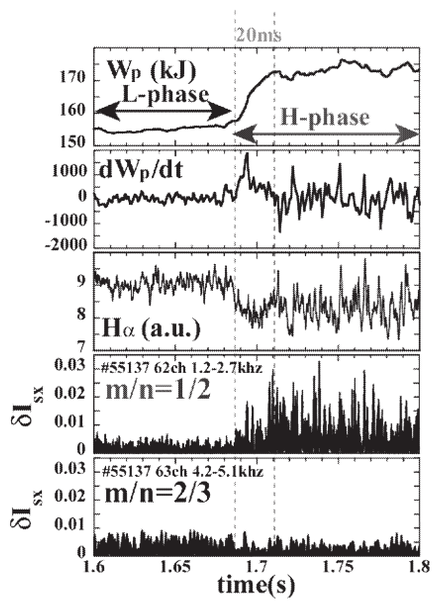

Fig. 1 Time evolutions of an L-H transition plasma at B_t = -1.0T, R_{ax} = 3.6m, γ = 1.20.

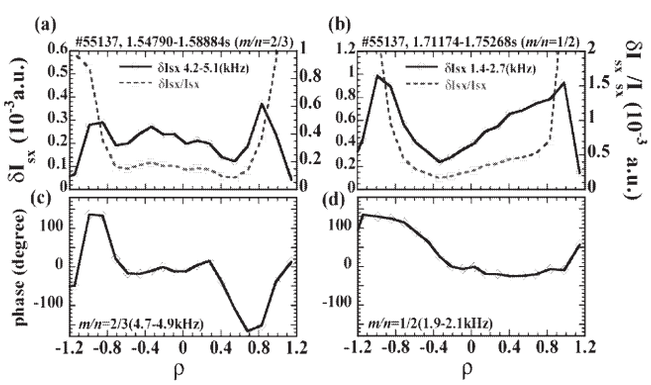

Fig. 2 (a, b) Radial profiles of SX fluctuation amplitude (δI_{sx}) and normalized SX fluctuation amplitude ($\delta I_{sx}/I_{sx}$) of m/n = 2/3 and 1/2 coherent modes. (c, d) Phase difference among SX channels for these modes.